# STUDIES IN NATURE CONSERVATION

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VOLUME I

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Thesis
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**STATEMENT OF ORIGINALITY**

This volume contains a substantial part of my research contribution to the conservation of nature. It consists 110 refereed papers or book chapters, one invited editorial and one chapter from a sole-authored book. None of this work has been submitted by me as part of a thesis for any other degree, although many papers have been adapted from theses written by the many honours and postgraduate students I have supervised since 1973 (Table 1).

I am sole author of 22 of the writings included in this volume. As can be gauged from Table 1, which outlines the contributions of the various authors of papers contained herein, and from the acknowledgements in the papers, I have benefited from working with many outstanding research students and colleagues, among them: Kerry Bridle, David Bowman, Mick Brown, Kath Dickinson, Rod Fensham, Neil Gibson, Louise Gilfedder, Stephen Harris, Chris Harwood, Tony Moscal and Jenny Scott. I could not have undertaken this work without the help of the general staff of the School of Geography and Environmental Studies and its predecessor academic units.

I declare the above information to be true

kpatrick 25 July 2005

Table 1. Contribution to papers with multiple authors. Estimated percentages are shown. n.a. = not applicable, * paper developed from the thesis of a student co-author who I supervised. + see table of contents for paper codes.

| Paper+ | Conception | Data collection | Data analysis | Writing up |
|---|---|---|---|---|
| 2.2 | 50 | 50 | 90 | 95 |
| 2.3 | 60 | 50 | 90 | 95 |
| 2.5 | 50 | 20 | 30 | 30 |
| 3.1.3 | 100 | 50 | 100 | 95 |
| 3.1.4 | 50 | 50 | 80 | 95 |
| 3.1.6 | 100 | 50 | 70 | 95 |
| 3.1.7* | 40 | 0 | 10 | 50 |
| 3.1.8 | 100 | 50 | 80 | 90 |
| 3.1.9 | 100 | 0 | 50 | 80 |
| 3.1.10* | 50 | 5 | 10 | 50 |
| 3.1.11* | 40 | 5 | 10 | 50 |
| 3.1.12* | 40 | 5 | 10 | 50 |
| 3.1.13* | 40 | 0 | 0 | 50 |
| 3.1.14* | 60 | 0 | 20 | 60 |
| 3.1.15* | 50 | 5 | 10 | 60 |
| 3.1.16 | 100 | 50 | 100 | 95 |
| 3.1.17 | 60 | 0 | 100 | 80 |
| 3.1.18 | 25 | 0 | 100 | 80 |
| 3.2.2* | 60 | 5 | 70 | 80 |
| 3.2.3 | 70 | 50 | 70 | 90 |
| 3.2.4* | 50 | 0 | 0 | 50 |
| 3.2.5* | 30 | 0 | 0 | 50 |
| 3.2.6* | 30 | 0 | 0 | 50 |
| 3.2.7* | 30 | 0 | 0 | 50 |
| 3.2.8* | 50 | 20 | 20 | 50 |
| 3.2.9 | 70 | 5 | 50 | 60 |
| 3.2.10 | 100 | 30 | 50 | 95 |
| 3.2.11* | 70 | 0 | 10 | 20 |
| 3.2.12* | 70 | 5 | 10 | 50 |
| 3.3.1 | 50 | 50 | 100 | 95 |
| 3.3.2 | 50 | 70 | 100 | 95 |
| 3.3.3 | 50 | 50 | 100 | 95 |
| 3.3.4 | 50 | 30 | 70 | 95 |
| 3.4.1 | 70 | 50 | 100 | 95 |
| 3.4.2 | 70 | 50 | 100 | 95 |
| 3.5.1 | 50 | 5 | 100 | 95 |
| 3.5.2* | 50 | 5 | 5 | 50 |
| 3.5.3* | 50 | 0 | 20 | 50 |
| 3.5.4* | 50 | 0 | 10 | 50 |

| Paper | Conception | Data collection | Data analysis | Writing up |
|---|---|---|---|---|
| 3.5.5 | 100 | 20 | 80 | 95 |
| 3.5.6* | 50 | 10 | 30 | 50 |
| 4.2 | 50 | 0 | 100 | 95 |
| 4.3* | 50 | 0 | 20 | 50 |
| 4.4* | 40 | 0 | 10 | 50 |
| 4.5* | 40 | 0 | 10 | 50 |
| 4.6* | 40 | 0 | 10 | 50 |
| 4.7* | 40 | 0 | 10 | 50 |
| 4.8 | 50 | 0 | 80 | 95 |
| 4.9 | 50 | 0 | 80 | 95 |
| 4.10 | 40 | 0 | 50 | 60 |
| 4.11* | 40 | 5 | 20 | 50 |
| 4.12* | 40 | 5 | 10 | 50 |
| 4.13* | 50 | 0 | 50 | 50 |
| 5.5* | 70 | 20 | 80 | 60 |
| 5.6* | 30 | 20 | 30 | 10 |
| 5.7* | 60 | 0 | 50 | 70 |
| 6.1.1 | 100 | 50 | 100 | 95 |
| 6.1.3 | 50 | 0 | 80 | 95 |
| 6.1.5 | 50 | 0 | 100 | 95 |
| 6.1.6* | 60 | 0 | 40 | 50 |
| 6.1.7* | 40 | 0 | 40 | 40 |
| 6.1.8 | 60 | 0 | 50 | 30 |
| 6.2.1 | 50 | na | na | 90 |
| 6.2.2* | 40 | 0 | 40 | 50 |
| 6.2.3* | 50 | 0 | 30 | 50 |
| 6.2.4* | 50 | 0 | 30 | 50 |
| 6.3.1 | 80 | 0 | 100 | 95 |
| 6.3.2 | 80 | 30 | 100 | 95 |
| 6.3.3* | 25 | 0 | 0 | 20 |
| 6.3.4* | 50 | na | na | 50 |
| 6.4.1 | 50 | 50 | 40 | 50 |
| 6.4.2* | 40 | 0 | 30 | 50 |
| 6.4.3* | 40 | 30 | 30 | 50 |
| 6.4.4* | 20 | 0 | 30 | 30 |
| 6.4.5 | 60 | 0 | 100 | 95 |
| 6.4.6* | 30 | 0 | 30 | 20 |
| 6.4.7 | 80 | 20 | 100 | 95 |
| 6.5.2* | 50 | 5 | 50 | 50 |
| 6.5.3* | 50 | 5 | 30 | 40 |
| 6.5.4 | 50 | 50 | 50 | 50 |
| 6.5.5 | 80 | 0 | 90 | 80 |
| 6.5.6 | 70 | 0 | 80 | 80 |
| 7.1* | 70 | na | 20 | 30 |

| Paper | Conception | Data collection | Data analysis | Writing up |
|---|---|---|---|---|
| 7.2 | 100 | 60 | 100 | 95 |
| 7.5 | 80 | 40 | 80 | 70 |
| 7.7 | 100 | 50 | 90 | 95 |
| 7.9 | 50 | 50 | 50 | 80 |
| 7.10 | 90 | 50 | 80 | 95 |
| 7.12* | 70 | 0 | 10 | 20 |

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## INTRODUCTION

The papers enclosed in this volume were all created with one major motivation, to contribute to the conservation of nature, defining nature in its dualistic sense. In paper 1.1, I described several ways in which biogeographers/ecologists can help create positive outcomes for nature through the research work that they choose to undertake, ranging from revealing interesting stories that might arouse public interest in nature conservation to the provision of a technical and knowledge foundation for conservation measures in matters of public dispute. Paper 1.2 argues the proposition that the particular may be more important than the general in gaining the types of ecological understandings that might enable practical nature conservation. Some of the ethical underpinnings of my research work are discussed in paper 1.3, the main, and unexceptional, point being that ecologists should base their public utterances on an honest reading of their always inadequate data. Attachment to ideas/generalizations/hypotheses can be bad for both science and the living world. The few people who will read this volume will probably pick up some instances of hypothesis drift, where the initial guiding proposition proves less interesting than a byproduct of the research process, and many instances of hypothesis reversal, where an idea that seemed excellent in relation to the data available at the time proves to be incorrect in a context of more data or a wider understanding.

The work in the present thesis was focused largely on Tasmania, a State of islands in the Commonwealth of Australia, constituting approximately 6.9 million ha of land, of which approximately 70% had not been cleared or inundated by 2005. The late Professor Bill Jackson believed that plant ecologists could only be proficient in their trade by knowing an area for decades. Whatever the truth of this proposition, longevity in a place does allow decades scale observations that can often be more powerful than natural or induced experiments in contributing towards an understanding of natural processes (e.g. 6.3.2, 3.1.16; 3.1.17; 5.4). The size and environmental heterogeneity of Tasmania have made it an excellent laboratory for the development and testing of ecological and conservation planning ideas and techniques, many of which have much wider relevance than to one small set of islands.

Before 1970, Barber (1955) and Barber and Jackson (1957) had used observations of genecological variation in *Eucalyptus urnigera* on Mt. Wellington to first postulate the phenomenon of divergence through selection in continuous populations, and Jackson (1968) had created a probabilistic ecosystem model that predicted successional change in lowland western Tasmania in an obscurely published paper way ahead of its time. In 1970, there was relatively little other published knowledge of the plant ecology of Tasmania, and, thus, little basis for determining conservation priorities for species and vegetation types, in a decade of expansion of conservation reserve systems in all parts of Australia, and elsewhere in the world. The literature that existed consisted of broad overviews of the vegetation (Jackson 1965, 1968), a body of work on the dynamics of tall eucalypt forests (Gilbert 1959; Cremer and Mount 1965) and a small number of descriptions, of varying depth, of the vegetation of small parts of the State (e.g. Gibbs 1920; Martin 1940; Davis 1941; Curtis and Sommerville 1947; Gillham 1965). I opportunistically added to this small body of descriptions, selecting some out of the many places that no-one had studied (e.g. Kirkpatrick 1973, 1975; 3.1.4; 3.1.5). Many of the areas I described were almost immediately made into conservation reserves, on the basis of a scientific description being available. It was obvious to me that scientific description was a poor selection criterion for reserves for nature conservation, given the almost total lack of knowledge of the vegetation and flora of most of the State. I thought that the collection of vegetation and species distribution data on a State-wide basis would be necessary to make possible an ecologically appropriate selection of reserves. The provision and analysis of these data became a major focus of my research.

Since 1977, when the first such study was published (Kirkpatrick 1977), State-wide surveys, based on quadrats or releves, have covered all the major vegetation types of Tasmania. The surveys in which I was principal investigator, or supervisor, were of coastal heath (Kirkpatrick 1977; Kirkpatrick and Harris 1999), lentic wetlands (3.5.1; Kirkpatrick and Harwood 1983; Kirkpatrick and Tyler 1988), alpine vegetation (3.1.1; 7.4; Kirkpatrick 1997), grasslands and grassy woodlands (7.5; Kirkpatrick *et al.* 1988; McDougall and Kirkpatrick 1994; Kirkpatrick *et al.* 1995), wet eucalypt forest

(Kirkpatrick *et al.* 1988), *Sphagnum* bogs (Whinam *et al.* 1989), coastal vegetation (Kirkpatrick and Harris 1995), rock plate vegetation (Gilfedder *et al.* 1997) and riparian vegetation (3.5.2). A synopsis of this work, and that conducted by others, to the mid 1990s, was published in Kirkpatrick *et al.* (1995) and its influence is discussed in paper 7.1. I was also involved in the first State-wide survey of coastal sage scrub in California (3.4.1 and 3.4.2).

The only vegetation map of Tasmania was small scale and differentiated only the major formations (Davies 1964). A map better suited to conservation planning was needed. I was involved in the creation of a 1:500,000 vegetation map for the State (Kirkpatrick and Dickinson 1984), and later developed a 1:25,000 vegetation mapping technique (7.6) which has been used to map the whole of the Tasmanian Wilderness World Heritage Area. The field work for the State-wide mapping was somewhat depressing, in that large areas of native vegetation were in the process of clearance, or had just been cleared. I took advantage of the availability of LANDSAT images from 1972 onwards to document the scale and patterning of this clearing (6.1.1 and 6.1.2).

After the pioneering work of Brown *et al.* (1977), I began organizing a data base of the occurrence of vascular plant species in the Tasmanian reserve system, in order to develop priorities for further reservation (Brown *et al.* 1983; Kirkpatrick *et al.* 1991; 7.7). I was later involved in work to document the distribution and reservation status of bryophytes in Tasmania (Moscal and Kirkpatrick 1997; Moscal *et al.* 1997). In the process of undertaking this work it became apparent that there was a need for work on the conservation ecology of threatened plants. This became a major focus of work in my research group from the late 1980s onwards (for a selection of papers, see 4). Many of the threatened species were largely confined to vegetation remnants in the most cleared and developed parts of the State. I therefore decided that it was important to understand how the attributes of remnants affected their biological and conservation attributes. Work to date has been done on vascular plants, bryophytes, lizards and birds (see 5 and 6.1.5 to 6.1.8). Different biotic groups have proven to respond very differently to the characteristics of remnants, and there proved to be no consistent relationship between the condition of the stands and their importance for threatened elements of biodiversity. For most species, the geometric characters of stands were irrelevant to their survival, and management was critical.

Management was also obviously important for the conservation of non-remnant vegetation. Work on the impacts of trampling by people revealed globally low thresholds for damage in Tasmanian alpine and subantarctic ecosystems (6.5.2 and 6.5.4). The impacts of trampling by horses were shown to vary between different alpine vegetation types (6.5.3). In the first major study of its kind, the impacts of disposal, by burial, of human wastes in the wild country were investigated (6.5.5 and 6.5.6), indicating minimal damage to the vegetation, but waste persistence for at least two years in high rainfall, acid environments.

The alpine vegetation of Tasmania was also very much influenced by fire. Recovery from a single incidence of fire was shown to be exceedingly slow (6.3.1 and 6.3.2), as was recovery from the combined effects of past sheep grazing and fire (6.4.1 to 6.4.3). Fire management was obviously critical in conserving the World Heritage qualities (Kirkpatrick *et al.* 1993) of Tasmanian alpine ecosystems. Most fires started in lowland sedgelands and heaths, making an understanding of their fire management critical in the conservation of alpine vegetation (6.3.4).

Our work on rare or threatened species, and on remnants, and earlier work comparing roadsides and adjacent bush (Fensham and Kirkpatrick 1989), had suggested that vertebrate grazing was playing a major role in determining the species composition and native species richness of lowland grassy vegetation, as well as high country vegetation. The big gaps in understanding were the relationship between grazing regime and vegetation, and the interactions of fire, grazing and vegetation. These were investigated using experimental manipulation and observation (6.4.6 and 6.4.7).

The woodchip export industry, established in the early1970s in Tasmania, resulted in a massive expansion of logging activity in Tasmania, and a change from selective logging to clearfelling in the dry eucalypt forests of the State. This was controversial (6.2.1). Research projects on the dynamics of montane eucalypt forests (3.2.4 to 3.2.7) and the comparative impacts on natural vegetation of clearfelling and selective logging (6.2.2 and 6.2.3) were initiated to determine some of the conservation consequences of this silvicultural change.

While most of my research has been in native vegetation outside cities, I was the first researcher in Australia to become interested in the ways in which native ecosystems responded to envelopment by city and suburbs (see 5), and among the first in Australia to take an interest in the plant ecology of the suburban garden (5.7).

Research directed towards improving the conservation of nature in Tasmania required some methodological innovation. I developed the first technique to optimize the selection of reserves (Kirkpatrick *et al.* 1980; 7.3), an achievement recognized by those who have further developed these selection processes (Pressey 2002; Williams *et al.* 2004). I also developed the first technique to quantify wilderness value and calculate its potential loss to development (Kirkpatrick 1979; 7.2), and, with Louise Mendel, devised a method for quantifying natural aesthetic value (7.12). In other methodological research, M.J. Brown and I made the first comparison of the effectiveness of environmental domain techniques and incomplete biological data as inputs to reservation planning (7.9) and M. Fowler and I developed a technique to locate Last Glacial refugia (7.10).

Nature conservation outcomes result from political and social processes as much as scientific understanding. Several of the papers I have included in this volume describe and analyse these processes (1.3, 5.7, 6.1.3, 6.1.4, 6.5.1, 7.1, 7.11).

Pure biogeographical and ecological research can be important for nature conservation either by providing interesting stories that bolster a conservation case, or by increasing understanding of patterns and processes that later turn out to be important in conservation planning or management. Section 2 of the thesis contains floristic biogeographic papers, the earliest of which (2.1) was on alpine floras in Australia. In doing the analysis for this paper I discovered that the commonly used similarity measures, Sorenson and Jaccard, did not produce reasonable classification and ordination outcomes when some mountain floras were subsets of the flora of larger mountains. I therefore used the number of species in common/the number of species that could be in common. This, and paper 2.4, established that there was a floristic continuum from the oligotrophic superhumid mountains of far southwestern Tasmania to the more fertile, drier and less glaciated mountains of northeast Tasmania and mainland Australia, with most of the variation being in Tasmania. An analysis of the biogeography of vascular plant endemism in Tasmania (2.2) showed the same continuum of variation and also emphasized the role of dolerite, a rock uncommon on mainland Australia. Another paper (2.3) revealed strong centres of local endemism, centres that seemed consistent with a refugium hypothesis, and which were therefore highly important for conservation planning. A graph in paper 2.1 showed a strong relationship between the percentage of endemic species and rainfall, but with the southernmost floras in a line parallel to, and below, the northernmost floras. This led to the investigation reported in paper 2.5, in which strategic rainfall data collection and remote sensing were used to establish that the precipitation maps on which the figure was based were incorrect, with the mountains in the far south receiving the highest precipitation in the State. The technique described in this paper can be adapted to any other areas lacking a reasonable spread of meteorological stations.

Much of my ecological research has been in high mountain and high latitude environments (see the selection of papers in 3.1 and Kirkpatrick 1997). The work in Tasmania contributed substantially to the case for the listing of Tasmanian Wilderness World Heritage Area, demonstrating the globally unusual nature of Tasmanian alpine ecosystems, a distinctiveness relating to a highly maritime climate, oligotrophic soils and isolation (Balmer *et al.* 2004). Several phenomena were researched in detail, for example: the dynamics at different temporal scales of ecosystems dominated by cushion plants; the nature and cause of a sharp floristic boundary between alpine and sedgeland vegetation in southwestern Tasmania; the characteristics and dynamics of unusual fjaeldmark vegetation; the ecology of the two species in the genus *Athrotaxis*; the dynamics of vegetation with *Sphagnum*; changes in the vegetation of the Australian Subantarctic islands.

Other ecological work has been on eucalypt-dominated vegetation (see the selection of papers in 3.2), tropical vegetation in Fiji and the Northern Territory (see the selection of papers in 3.3), Californian vegetation (see the selection of papers in 3.4), wetland vegetation (e.g. 3.5.1 and 3.5.2) and coastal vegetation (e.g. 3.5.4 and 3.5.5). With my students and other colleagues, I have undertaken at least some work on all major terrestrial Tasmanian vegetation types. My work on eucalypts contributed to my major role in the development of the eucalypt-dominated vegetation theme for World Heritage assessment. This theme contributed to the expansion of the listing of the Tasmanian Wilderness in 1989 and the later listing of the Blue Mountains, and played a major role in an influential natural heritage assessment of the Australian Alps (Kirkpatrick 1994).

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